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## OF
# THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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VOL. IX. MARCH, 1915 No. 3

A Meteorological Trip to the Arctic Circle - - *J. Patterson* 101
Is There a Morning Maximum of the Aurora - - *A. F. Hunter* 121

**Meetings of the Society**
At Hamilton - - - - - - *T. H. W.* 126

**Notes from the Dominion Observatory**
The Radial Velocity of 1 Cassiopeiæ - - *W. E. Harper* 128

**Review of Publications** *W. E. Harper* 130

**Notes from the Meteorological Service**
Report of the Weather in Canada, February - *R. F. S.* 134
Earthquake Records at Toronto and Victoria, B.C. *J. Y.* 137
Magnetic Observations - - - - *R. F. S.* 138

**Comet News**
The Orbit of Mellish's Comet - - - *C. A. C* 139

**Astronomical Notes**
Recent Stellar Work at Mount Wilson Solar Observatory 141
Gravitation - - - - - *J. R. C.* 143

**Notes and Queries** 145
Velocities of the Nebulæ and the Stars - - 146
Electrical Phenomena on Mt. Hamilton - - *C. A. C.* 147

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Photo by Campbell Young, Edmonton.

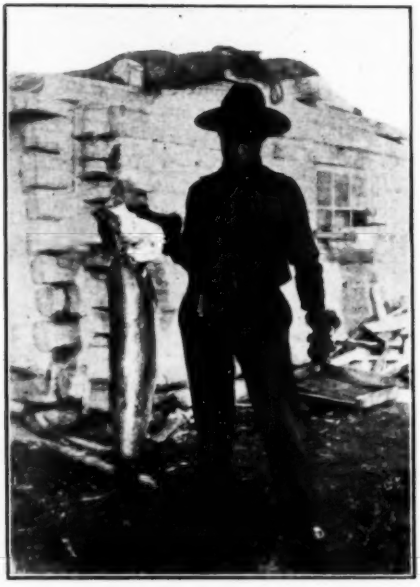
FORT RESOLUTION WITH ROMAN CATHOLIC CHURCH IN FOREGROUND

All the 'forts' on the Mackenzie resemble this

NORTHERN TRADING'S CO'S. BUILDING AT FORT NORMAN.

(Lat. 64° 55' N.). Wild roses in bloom in the foreground. June 30, 1914.

CULTIVATING POTATOES AT HAY RIVER. (About July 1).



THIRTY-NINE POUND INCONNU. (*Stenodus Mackenzii*).
Caught by the R.N.W.M.P. at Fort McPherson, July 15, 1914.
This specimen is now in the University of Toronto Museum.

Photo by Campbell Young, Edmonton.
LARGE GLOBULAR CONCRETIONS IN SOFT SANDSTONE AT THE GRAND RAPIDS, ATHABASKA RIVER.

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# A METEOROLOGICAL TRIP TO THE ARCTIC CIRCLE

By J. Patterson

THE purpose of my trip was to inspect the meteorological stations in the Mackenzie River Basin and to equip two stations in the Arctic regions, Fort Good Hope, Lat. 66° 16′, Long. 128° 54′, and Fort McPherson, Lat. 67° 27′, Long. 134° 51′, as well as to supply the Canadian Arctic Expedition with instruments and materials for despatching balloons and following them with theodolites, in order to get the velocity and directions of the air currents in the upper atmosphere; an investigation undertaken by an International Meteorological Committee. To carry out the latter it was necessary to take a large quantity of material, and to do the former to go by a small boat or canoe most of the way. Steamers ply on the Mackenzie from Fort Smith to Fort McPherson, a distance of 1300 miles, but as they only stop for a few hours at each post at any time of the day or night, it was not possible to travel on them and to properly inspect the meteorological observatories.

The present route down the Athabaska River from Athabaska Landing has been used since the advent of the railway to

Edmonton, but before that time it was by way of the Churchill and Clearwater River to its junction with the Athabaska, after which the routes were the same. It is, perhaps, fortunate that by the present route all the rapids occur in the first 250 miles of the journey from the Landing to Fort McMurray at the junction of the Clearwater. Only barges, scows and small boats can navigate this portion of the river and then only with skilful steersmen who know every crook and turn in the river.

The great industry in all this region, is of course that dealing with fur, and ever since Peter Pond in 1778 guided his frail bark down the Clearwater and the Athabaska, this region has been noted for its furs, and to-day is probably the chief fur region in North America. All trade in this vast area is thus primarily in connection with the fur trade and will remain so until transportation is such that the country will be easy of access by railway to Ft. McMurray. Yet even now prospectors, surveyors and free traders are making their way into the country. The Hudson Bay Company is the largest and best known company to-day in that part, and ever since the amalgamation of the old Northwest Fur Trading Co. with the Hudson Bay Co., they have unitedly fought just as strenuously to keep all other traders out, as formerly they fought each other; so successful have they been in this that at the present day they have only one serious rival in the whole of the region and that is the Northern Trading Co.

In addition to these two companies, independent traders, taking in a small outfit, trade and trap for a winter and return the next season by way of the Yukon or the Mackenzie.

The Northern Trading Company agreed to furnish me with transportation ahead of the steamers to enable me to do my work properly, and Mr. Campbell Young, the General Manager, was most obliging and arrangements for me very satisfactory. They set out on May 4th from the Landing with ten scows, a crew of between forty and fifty and about ten passengers; the scows are 60 feet long, 12 feet wide and 3 feet deep and hold from 6 to 9 tons according to the stage of the water in the river;

each scow costs $150.00 and is manned by a steersman and two or three oarsmen who have to be fed and supplied with tobacco in addition to their wages ; so all told it costs about $500.00 to get a scow down to Ft. McMurray, a distance of 250 miles. The motive power is the current which runs fairly steadily at from 3 to 4 miles an hour, the men row little, except to keep the boat in the current and at the rapids ; the first 120 miles are passed without incident, except that, for some distance from the Landing, evidence of the forward march of civilization is seen in the farm houses dotted here and there along the banks, then solitude reigns until one approaches the Pelican, the first rapid, where derricks proclaim the presence of the prospector and the oil region : so far they have had only prospects of oil, but in one of the wells sunk 16 years ago gas was struck and it has been burning ever since, wasting enough gas to light many of the cities of the West ; its roar can be heard a mile away and by night the illumination is visible to great distances. Here the troubles begin ; the river is shallow and swift, and I had my first exhibition of boat repairing in an emergency as one of the scows struck on a rock and was punctured. A case of crisco was convenient and was broken open with one blow of an axe, the contents were quickly softened in the mouths of the boatmen and then plugged into the hole, a board being nailed over the top to hold it in place, and the operation was done.

Passing through three small rapids, the Grand Rapids of the Athabaska were reached 6 days after setting out. Above this point the soil is clayey, but here a soft sandstone formation filled with globular concretions appears and the river has cut a deep channel through it, which is filled with these enormous boulders ; the fall amounts to about 80 feet in less than a mile and an island in the centre of the river divides it into a main channel which is not navigable, and a smaller one through which scows can be run partly loaded in high water and empty in low water ; all the cargo is unloaded at the head of the island and taken across on a tram-line, the property of the Hudson Bay Co., who charge $2.00 a ton for the privilege of getting the freight across,

MAP OF THE MACKENZIE RIVER BASIN

you doing all the work yourself, even to furnishing the motive power for the tram-car. The scows are run through the channel and then hauled up to the loading place, loaded up and started again. It required about ten days to work all the scows through. After leaving the Grand Rapids one passed in succession, the Brulé, Boiler, Middle, Long, Crooked, Stony, Little Cascade, Grand Cascade, Mountain and Moberly. At the Boiler, so called because the Hudson Bay Co. lost a boiler there many years ago, the tar sands appear and then at the Stony the river runs through a limestone bed. The rapids now consist chiefly of small cascades, which in high water are almost blotted out. The most important of them is the Grand Cascade, where there is a fall of about 6 feet in low water; here the scows have to be unloaded and the goods portaged across, after which the scows are let down by ropes and then reloaded. The portage is less than 100 yards but the banks are steep, and one gets a fine exhibition of how not to handle articles labelled "glass with care," for unless you are there to personally look after such property it will receive the same treatment as the bags of flour, sacks of pork and such merchandise. After leaving this rapid it is only a short run to Ft. McMurray and the first stage of the journey is over. The rivermen return by trail to the head of the Grand Rapids to bring the next fleet of scows through. A halt is made for a day at McMurray, the scows are tied together, two and two, and one steersman and two oarsmen assigned to each pair; everybody except the passengers having to work, and even they, from sheer desire to vary the monotony of having nothing to do but sit or lie about, are glad to relieve it by taking an occasional turn at the oars. Sometimes the scows are towed by a small steamer from here to Smith Landing, but owing to the low water the tug towing the Hudson Bay Co's. scows passed us with flying colors soon after leaving McMurray, but it had not gone far when it stuck on a sandbar and did not catch up again for a week. Chipewyan is the next objective and as one approaches Lake Athabaska on which it is situated, the ducks and geese become more numerous, the lake a verit-

able sportsman's paradise; the ducks and geese breed around the shores of the lake and in the fall of the year countless number of them are found. It is to be hoped that when the place becomes easy of access by the railway to Ft. McMurray, that the Government will adopt stringent regulations to prevent their extermination. Ducks are found in great numbers along the rivers and lakes all the way to the Arctic, but they are wild and it was not possible to fill the larder with them without losing much time, and as our work demanded haste we had to hurry on. Chipewyan was reached on the 1st of June; it is the most historic fort of the north, for it has been in existence since 1788 when it was founded by a cousin of Sir Alexander McKenzie; it was from here that Sir Alexander set out on his memorable voyages to the Arctic and Pacific, and that Sir John Franklin outfitted for his journeys to the Arctic. It now has an Anglican and a Roman Catholic mission, the latter having a large school, sawmill, farm, and several steamboats for the fisheries and for visiting the outlying stations. The Hudson Bay Co. has a serious rival in Colin Fraser, son of Sir George Simpson's famous piper, who has recently built a fine gasoline boat that plies between Ft. McMurray and Smith Landing. This boat towed the scows across the lake and to the mouth of the Peace River. The Peace River when Lake Athabaska is low flows both ways so that it is necessary to row, tow or sail the scows that far before they again get the current and can look out for themselves. After much bad weather Smith Landing was reached on the 9th of June, five weeks after leaving Athabaska Landing. By this time the ubiquitous mosquito was at the height of his career, making life miserable for man and beast; there is no escape except by drowning or protecting yourself with mosquito netting. At Smith Landing the river is obstructed by several very dangerous rapids, through which it is impossible to take scows. Formerly the rapids were passed by several portages, but now a wagon trail has been cut to Ft. Smith (16 miles) and all merchandise is freighted across on wagons. The horses, however, looked as if they had all they could do to get themselves across, let alone

taking a load, as it is, the loads vary from 12 to 20 cwt. Smith Landing is the headquarters of the mounted police for the district and the Indian agent lives at Ft. Smith. He is also postmaster, fire ranger, superintendent of the Government Farm and overseer of the reindeer obtained from Labrador, of which there is only one solitary representative remaining. The Catholic Mission opened a fine school and hospital there this season (1914). Ft. Smith is at the head of navigation of the Mackenzie system, and steamboats ply from here to the Arctic (1300 miles). Leaving by the Northern Trading Company's steamboat on June the 12th, we arrived the next day at Ft. Resolution on Great Slave Lake only to find that the wind had blown the ice in shore and that it was impossible to make the fort even with a small rowboat, as the ice was thin, much broken up and rotten and filled up the shallow waters of the bay right to the shore. The ice went out the next day with an off-shore wind, and allowed us to get in. From here arrangements had to be made for me to proceed the rest of the way by canoe. I was fortunate in being able to accompany Bishop Breynault, of the Oblate Fathers of Brittany, France, who carry on the Catholic Mission throughout the Mackenzie, as far as Ft. Providence. We set out on June 16th for Hay River, and were stopped that night by ice, but an off shore wind springing up in the morning enabled us to proceed and except at Sulphur Pt. (so called from the deposits of sulphur found there) where the ice blocked our way. It was piled up 20 or 30 feet high in places and delayed us for some hours so that we did not arrive at Hay River until after 2 a.m. Hay River, at the mouth of a river of the same name, is flat and only a few feet above the level of the lake. The Church of England Mission has an excellent school here and a farm where they grow large quantities of potatoes and vegetables, but very little, if any, grain. The place is also noted as having the farthest north horse in the district and, I believe, also the farthest north cattle. Leaving Hay River the same day with a fair wind, I had my first sight of the mirage, which was very beautiful but made it difficult to find our way. We entered the Mac-

kenzie shortly after midnight, but at that time of the year it was still quite light. A halt was made for a few hours' rest, but as the fishing appeared to be good, the temptation to try the troll was too great to be resisted and we were successful in landing a large *inconnu*. This fish, so called by Sir Alexander McKenzie because he did not know it, is a member of the salmon family and is found as far up the river as Ft. Smith, where its further progress is stopped by the rapids. They look like large salmon trout and some weigh as much as 60 and 70 lbs., but the most of them that are caught weigh from 10 to 20 lbs. It is one of the staple food fishes in the region and is valued next to the white fish. The largest specimens are found between Ft. Good Hope and the Arctic and I have been informed that they are also found in the Yukon although never very large; it is caught usually in the nets, but it will take the troll and provides excellent sport. The staple food fish of the whole region is the white fish. Great Slave Lake teems with them and every year scow loads are obtained for all the posts within reach; they form the principle article of diet for both man and dog. It is an interesting fact that the white people never tire of the white fish, and from the few that I had the privilege of sampling, I could easily understand that it is so. Even the dogs have their tastes as well as man and they prefer the white fish, but if it is not obtainable they will eat inconnu, or as they are generally called connie, and if neither of these is to be had, well! under stress they will condescend to eat jack fish.

Shortly after noon of the day after we entered the Mackenzie I witnessed a most interesting phenomena, the formation of a thunderstorm right over us. Our first intimation of it was a few drops of rain, then a fair wind sprang up and we made good time; the shower was fairly heavy and after having passed us it seemed to stand still about a mile away; presently another and much heavier shower passed over and united with the previous one; the wind by this time had died down; a third cloud followed, by which time we were battling with a strong head

wind and lighting flashes were seen ; these phenomenæ continued until the whole sky was covered with black angry clouds from which ever and anon came vivid lightning flashes.

The current gradually became stronger and the same afternoon Ft. Providence was reached. Ft. Providence has a large Catholic school and mission and here I parted with the Bishop, who is not only a very interesting and agreeable companion but broad and liberal minded and highly respected throughout his diocese.

At Providence the Northern Trading Co. furnished me with a guide and a boat, and setting out the next day, the hundred miles of dead water was traversed without incident except a visit from an occasional Indian with whom we could generally trade some flour or tea, for fish, which formed a welcome change to our usual steady diet of bacon and bannock, and reached the Head of the Line, on the third day. It is here that the trackers in bringing up the York boats before the days of the steamboat were able to substitute the oars for the tracking line. At this place the river contracts to less than half its width and for the rest of the way the current runs from 3 to 8 miles an hour ; with this current it did not take long to reach Ft. Simpson at the junction of the Liard. The fort is built on an island and the breaking of the ice on the Liard is a most wonderful sight, but can only be witnessed by those who winter in the country. The Liard in its upper reaches is filled with dangerous rapids and the ice breaks in that part first ; it is forced down by the water and piled up on the ice below until the whole channel is blocked ; the water is thus held back until the pressure is sufficient to start another rush ; this is repeated again and again until it reaches the Mackenzie where at times the water rises until it almost overflows the island 40 ft. above the ordinary level of the river ; then as if gathering all its strength for a mighty onslaught, and with a terrific roar it crushes forward cutting a clear road through the ice right across the Mackenzie River. In the spring the Liard is very muddy, while the Mackenzie above the junction is beautifully clear and so great is the volume of

water flowing in these rivers that the waters are not thoroughly mixed for more than 100 miles below the junction. The Indians do not like to go far from home and that obliged me to change my guide at each post. The trip to Ft. Wrigley was made without incident, apart from the bush fires caused by the carelessness of the Indians, but my next guide who was to take me to Ft. Norman could not speak a word of English and I knew no Indian: we managed to understand each other quite easily, but conversation was limited. Just after leaving Wrigley he stood up in the boat and listened intently, then turning to me he shouted, the only word he apparently knew, "wind". I understood and we rowed for shore as hard as we could, just reaching it when the wind arrived and in a few minutes the river was running white. These squalls are very sudden and very fierce while they last, usually stirring up a very choppy sea that is liable to swamp any small craft that may get caught in them. The wind was now contrary and in order not to use up all one's energy rowing against the wind and being compelled to rest when the wind calmed down, resort was had to a water-horse. This is a small spruce tree about ten feet high with plenty of brush on it, on the end of which a stone is tied. Throwing it over-board, the tree sinks until about a foot of the top is above the water; the boat is hitched to this and the horse keeps in the strongest part of the current and takes you along almost as fast as the current. The boatmen can thus rest themselves and when it calms down take the oars again and make good time. In case of scows the plan is to use a water-sail instead of a wind-sail under similar conditions. The water-sail is simply a square sail tied on a mast and weighted at the bottom with stones so that it will sink; then if there is a side wind blowing, thus tending to blow the scow on shore, all that is necessary is to give the water-sail the proper angle and it will keep the scow in the strongest current. By this means it is possible to make good time against quite strong cross head winds. Time is an important factor and as it is light all night, instead of tying up, it is usual to make your bed as best you can in the canoe or boat and go to sleep allowing the

boat to drift all night. It keeps the current and as you occasionally wake up you find yourself turning round and round in an eddy; then getting free from it, the boat drifts on, one time at one side of the river and a little later at the other, thus, dodging the sandbars, but seldom sticking on them.

In this way Fort Norman was reached, at the junction of the Bear River, overlooking which is a high steep cliff called Bear Rock, and from which for a few days about the 21st of June the sun can be seen at midnight. Bear River is clear and cold, a delightful change from the mud that one has been accustomed to, from the Laird in the Mackenzie. Above Norman, smoke is seen issuing from the banks just as in Mackenzie's day. Few fish are caught between Providence and Norman but at this place the herring are numerous; they either go up to or come down from Great Bear Lake and in the fall of the year the inhabitants at Norman migrate to Great Bear Lake, for the herring fisheries, catching their winter's supply and bringing them down by scows. This is also one of the routes to Great Bear Lake and the Coppermine by the Dease River. It is also one of the best fur posts in the region, being specially noted for white foxes and caribou from the barren lands in addition to all kinds of foxes, martin, mink, etc.

My guide for the rest of the trip was a young Loucheux who had been to Hay River School where he learned English and cleanliness. On this portion of the river, the chief obstructions to navigation occur, the Sans Sault Rapids and the Ramparts. The approach to the rapids is indicated by wolverine rock, so called because one of the pinnacles looks somewhat like a wolverine and it is the bounden duty of every Indian to shoot at it, for the wolverine is his enemy, robbing his traps whenever the opportunity occurs. The Ramparts are the most interesting geological feature of the Mackenzie system. Above them the river is about three miles wide with a fairly strong current and as the Ramparts are entered it contracts suddenly to about 500 yards; yet in high water there is no sign of a rapid and the

current is only about five miles an hour. In low water just above the Ramparts there is a very dangerous rapid and a cascade with a fall of eight feet or more, making it dangerous for even a scow to go through. The Ramparts are formed by Devonian limestone rising from beneath the cretaceous through which the canyon is cut. The walls of the ramparts are vertical and rise from 100 to 250 feet above the river. It is frequently the scene of great ice jams and on one occasion the water is said to have risen over 100 feet and left a York boat stranded on top of the cliff. On emerging from the Ramparts, Ft. Good Hope, white and glistening, lay directly in front. Here the Northern Trading Co. and the Hudson Bay Co. have posts and as illustrative of the traditions of the Hudson Bay Co. and the loyalty of their servants it is said that the factor's little girl, at the Mission School at Providence, when asked why Adam and Eve were turned out of the Garden of Eden, replied that it was because they disobeyed the orders of the Hudson Bay Co.

It was necessary to make a stop here for several days to inspect the observatory and make arrangements for the despatch of balloons ; this was just finished when the boat bringing my supplies arrived and with the news that the Hudson Bay Co's. boat, the S.S. *Mackenzie River*, was, at least, a week behind ; this was good news to me for it meant that by hard work I could finish my work and return by the boat rather than cross the mountains and return by way of the Yukon. Stopping a day after the boat proceeded on its voyage, to finish my instructions to the observers, I again embarked and by travelling day and night reached Ft McPherson on the 12th July, the last day the sun was above the horizon at midnight, less than half being visible at its lowest dip. On this part of the trip, perhaps more than any other, one gets a view of the grandeur and immensity of the river. While drifting down between the high banks you do not realize the river is so big and you feel disappointed until you row across, but here it opens out and at one stretch called

the "Grand View" the river is straight with a water horizon before and behind for a distance of eighty miles.

The Eskimo from the delta of the Mackenzie make an annual pilgrimage to Ft. McPherson and Arctic Red River to trade when the steamers arrive; then they go to Herschell Island to meet the whalers from the Pacific. All that has been said about them in regard to their cheerfulness and business ability has not been exaggerated; they appear to be the happiest people I have ever met. The Church of England has a large and important work among them as well as with the Loucheux Indians.

Ft. McPherson is situated on Peel's River about thirty miles from its mouth, and until recently was the most northerly post of the Hudson Bay Co.; it was selected as the most suitable point from which to make the portage across the mountains to Rampart House and Fort Yukon, when these two posts were maintained by them, all the trade passing through McPherson.

One of the most interesting features of the trip down the river was the desire for information on the part of the white people and it made one realize how completely they are cut off from the outside world. The last news they had received was in regard to the Balkan War and they wanted to know how it ended, never dreaming that in a few days after that Europe would be plunged in war, about which they will not hear until March or later. Usually all the English-speaking people assembled and I tried to give them an account of the principal events of the past year.

On the 16th July, the S. S. *Mackenzie River* having discharged her cargo and taken on the fur, amid the shrieking of her whistle and the waving of handkerchiefs started on her long journey upstream, which was accomplished without incident. Between successive forts she had to spend several hours taking on wood and sometimes had to tie up and wait until the crew could cut enough wood to take her to the next fort. One evening there was great excitement when a large black bear was seen in the river in front of the boat. Every rifle on board was quickly

produced and when the bear was about seventy-five yards away they all opened fire, each one striving to be the first to hit poor bruin, but he was a strong swimmer and escaped.

The S.S. *Mackenzie River* is a splendid river boat, three feet in the water and over twenty feet out; but on the lake if the wind begins to blow the boat begins to roll, and as the cargo of furs must be kept dry it is not possible to cross the lake except when it is almost calm.

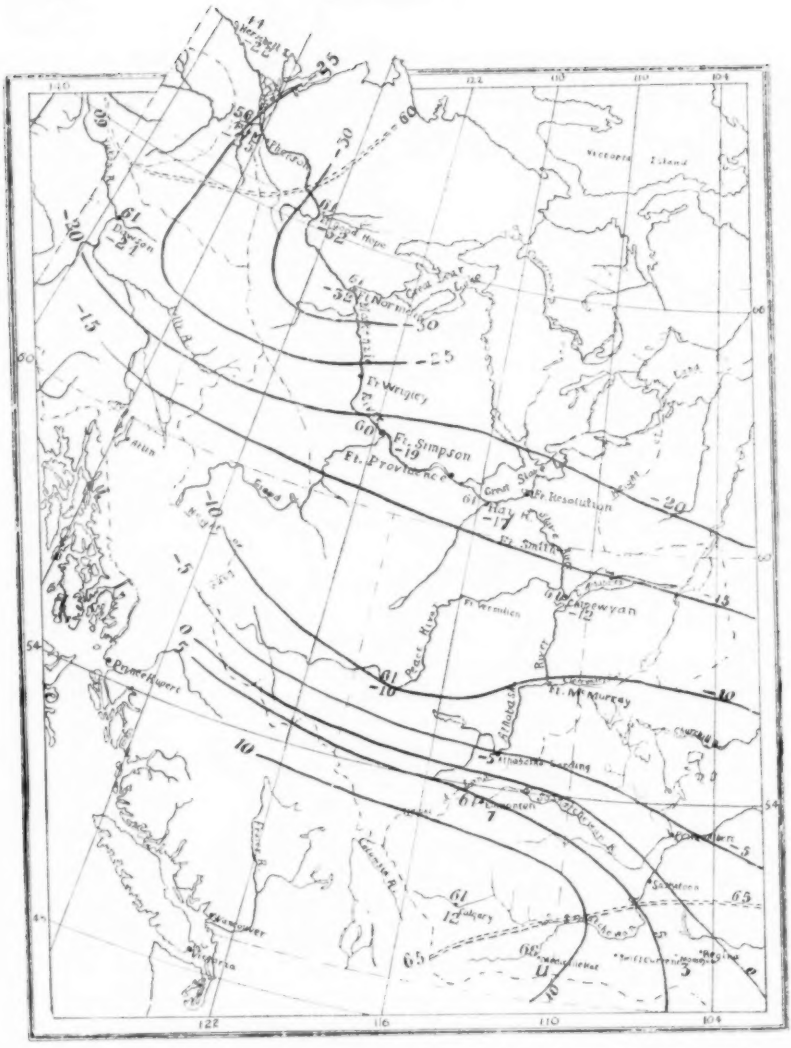
On the return journey a trip was made to Ft. Rae on the northern arm of Great Slave Lake. The Dogrib Indians usually trade at this place, and if those about the fort were representative of their tribe they are the most degenerate of all the Indian races.

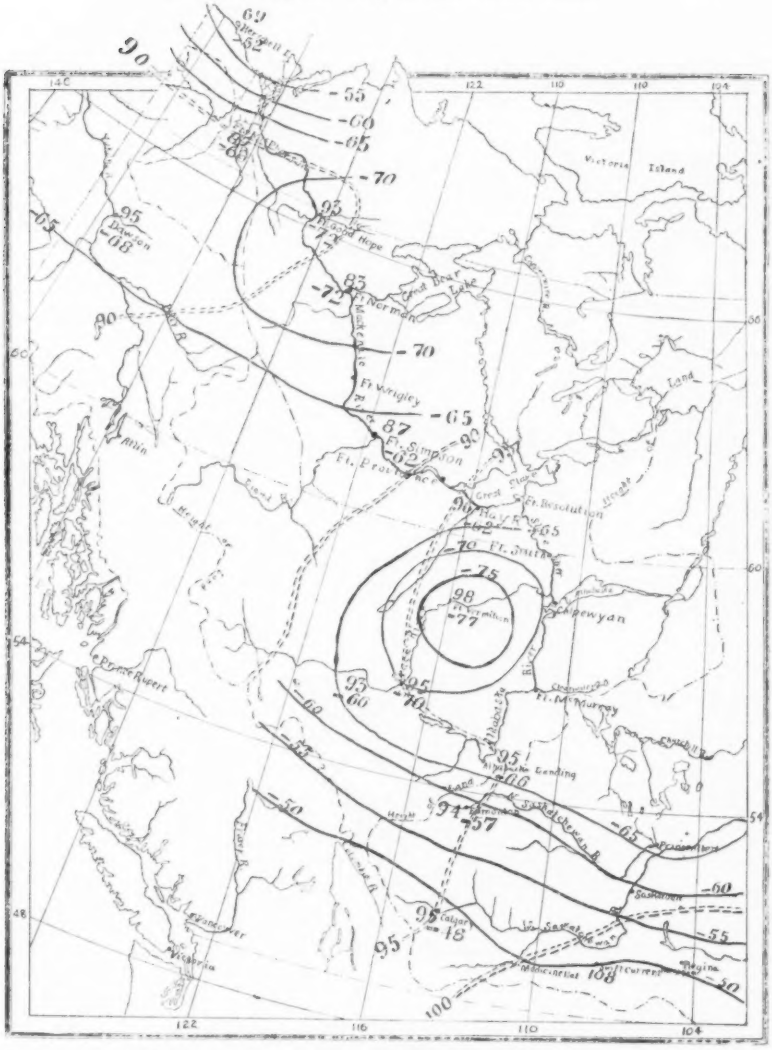
Ft. Smith was reached on July 30th and the cargo of fur transferred by wagon to Smith Landing, where the S. S. *Grahme* was waiting to convey us to Ft. McMurray, which was reached on August 5th. Now began the most difficult part of the trip, as all the cargo of furs had to be taken up through the rapids. This could only be done by loading it into scows and tracking or towing them up the river; each scow requires from six to ten men on the line, one man to steer and one in the bow to keep the scow off the stones. The rope is attached about a third of the way from the bow and this makes it an easy matter to keep the scow far out in the river: in fact, the line can be almost at right angles to the boat and still make good progress. In smooth water, even though the current is strong, the men travel at a good gait, but when they have to get the boat up the rapids it often requires a double crew on the line and the progress at times is barely inch by inch. Again, when a small fall has to be surmounted at a sharp bend in the river, it is necessary to throw a line on shore from the bow of the boat, and it requires the utmost strength of several men pulling the bow straight in shore to prevent the scow from being thrown out into the stream or turning around and breaking away. The weather was very hot; the men had to wade through mud knee deep, climb banks that were almost vertical, cross mountain torrents and surmount

rapids where all their strength had to be put forth for hours at a time. This gave one a glimpse of the labor involved and the price that has to be paid in getting the furs to the market. At the Grand Rapids the cargo had all to be packed for nearly half a mile and the scows pulled up through the boiling rapids; no one is allowed in them as there is very great danger of the scow being filled with water and swamping when surmounting some of the wildest torrents of the rapids. A steamboat came down to meet us above the rapids and everyone thought that tracking was over for the season, but at one of the rapids, above the Grand, the boat had not power enough to get over the crest and again the men had to get out the ropes and everyone taking hold managed to track the steamboat over the crest and then without further incident Athabaska Landing was reached on August 25th, just in time to get the train to Edmonton.

The Meteorological Service has stations at Ft. McMurray, Ft. Chipewyan, Ft. Smith, Ft. Resolution, Hay River, Ft. Simpson, Ft. Norman, Ft. Good Hope, Ft. McPherson and Herschell Island; at all these stations observations have been taken for some years, but owing to the primary work of the observer often taking him far afield, it has been difficult to obtain continuous records; in spite of the drawbacks, however, series of observations have been obtained which give a good indication of the climatological features of the area. As the heights of the stations above sea level are not known accurately, it has not been possible to reduce the barometer readings so that they can be compared with other stations in Canada.

In summer the weather is intensely hot and the sun's rays very strong, owing to the dry clear atmosphere. The chart showing the mean temperature for January and July shows the interesting fact that, from the Arctic Circle to the International Boundary mean temperature in July is between 60° F and 65° F. In the Arctic regions the ground never thaws out and at Ft. Good Hope is always frozen below three or four feet; the gradual thawing, however, gives some moisture to the soil and prevents failure of the vegetable crop through lack of rain. Temperatures over


Ft. Wrigley
Ft. Simpson
Ft. Providence
Ft. Resolution
Ft. Smith
Ft. Vermilion
Peace River
Ft. McMurray
Athabasca Landing
Edmonton
Calgary
Medicine Hat
Battleford
Prince Albert
Qu'Appelle
Winnipeg
Regina
Moosejaw
Swift Current
Saskatoon
Prince Albert
Battle R.
Peace R.
Athabasca R.
Slave R.
Mackenzie R.
Great Slave L.
Great Bear L.
Athabasca L.
Lake Winnipeg
Lake Manitoba
Lake Winnipegosis
Lake Athabasca
Lake Claire
Lake Athabasca




ABSOLUTE HIGHEST AND ABSOLUTE LOWEST TEMPERATURES RECORDED

Absolute lowest isothermals, heavy full lines.

Absolute highest isothermals, double dotted lines.

90° F. have been recorded in the region and the high air temperatures combined with continuous daylight make it possible to grow vegetables at all the posts. Potatoes seldom fail as far north as Ft. Good Hope but have apparently never been tried at Ft. McPherson, as seed would have to be brought in the year before it was planted.

In the winter months the long clear nights permit of intense radiation, thus causing extreme cold. The temperature steadily decreases northwards until Ft. Norman and Ft. Good Hope are reached after which temperature begins to rise as the Arctic is approached. This is well illustrated in the charts giving the lowest minimum recorded at the different places and the mean temperature for the month of January. They show that the region between Good Hope and Norman is the coldest on the North American Continent and corresponds to the region in Siberia between Latitudes 62° N. to 68° N. and Longitudes 110° E. to 135° E. of Greenwich; where mean temperature is 54° F. below zero during January. This region is in the same latitude as the Canadian zone and 100° of longitude west of it. The increase of temperature to the north of Good Hope does not mean that the climate is less severe for on the contrary it is more severe on both animals and plants.

The extreme range (the difference between the highest and lowest ever recorded) of temperature between summer and winter is very great and at Good Hope it is as much as 165° F.; at Toronto the extreme range is 130° F.

Rain-fall is light and occurs chiefly in July and August; it is sometimes accompanied by severe lightning and thunder as far north, at least, as Ft. McPherson. The snowfall is also light; in the Mackenzie River valley snow flurries sometimes occur in June and August but not in July.

The temperature and precipitation data are given in the following table.

Balloon observations in various parts of the world have shown that in the upper atmosphere a region is reached where the temperature ceases to decrease and after entering that region

TABLE GIVING THE MEAN TEMPERATURE FOR EACH MONTH, THE HIGHEST MAXIMUM, THE LOWEST MINIMUM, AND THE EXTREME RANGE AND YEARLY PRECIPITATION AT THE MACKENZIE BASIN

| Station | Lat. N. | Long. W. | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Highest Max. | Lowest Min | Extreme Range | Total Precipitation R | Total Precipitation S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | | | | | | | | | | | | | | ″ | ″ |
| Herschell Island | | | - 22·0 | - 12·3 | - 12·1 | 2·1 | 19·2 | 35·5 | 44·1 | 41·3 | 36·3 | 16·0 | 6·1 | - 14·5 | 69 | - 52 | 121 | | |
| Ft. McPherson | 67 27 | 134 51 | - 25·2 | - 21·8 | - 8·2 | 7·8 | 30·4 | 51·7 | 58·5 | 53·9 | 35·7 | 14·3 | - 10·2 | - 17·4 | 89 | - 68 | 157 | | 39 |
| Ft. Good Hope | 66 16 | 128 54 | - 31·6 | - 26·1 | - 12·3 | 14·5 | 35·1 | 56·3 | 61·2 | 53·0 | 38·7 | 16·6 | - 15·2 | - 25·0 | 93 | - 72 | 165 | 1·51 | 60 |
| Ft. Norman | 64 55 | 125 41 | - 32·2 | - 25·4 | - 12·0 | 14·7 | 35·9 | 57·0 | 61·2 | 53·0 | 38·8 | 15·9 | - 17·7 | - 25·4 | 83 | - 72 | 155 | 0·58 | 55 |
| Ft. Simpson | 61 52 | 121 10 | - 19·3 | - 17·9 | - 3·2 | 28·1 | 42·9 | 55·5 | 60·3 | 55·6 | 43·6 | 24·8 | - 0·7 | - 11·2 | 87 | - 62 | 149 | 8·71 | 68 |
| Hay River | 60 51 | 115 43 | - 16·8 | - 10·0 | 1·5 | 26·1 | 41·2 | 51·3 | 61·5 | 58·0 | 45·5 | 31·7 | 7·2 | - 6·0 | 96 | - 62 | 158 | | |
| Ft. Chipewyan | 58 43 | 111 10 | - 11·9 | - 9·1 | 5·0 | 28·5 | 44·5 | 54·0 | 61·5 | 58·1 | 45·2 | 33·7 | 11·0 | 2·2 | 93 | - 56 | 149 | 8·59 | 50 |
| Ft. Vermilion | 58 27 | 116 [illegible] | - 14·8 | - 3·9 | 11·8 | 32·0 | 49·3 | 57·9 | 61·0 | 57·1 | 47·3 | 33·1 | 14·0 | - 1·7 | 101 | - 77 | 178 | 7·52 | 36 |
| Fond du Lac | | | - 22·6 | - 16·2 | 2·3 | 18·6 | 38·4 | 53·4 | 58·8 | 54·4 | 44·2 | 32·5 | 11·0 | - 5·7 | 90 | - 61 | 151 | 7·53 | 28 |

the temperature is either constant or rises slightly ; this region is called the stratosphere and it is highest and coldest at the equator ; as one proceeds north or south from the equator, the stratosphere becomes warmer and approaches the earth ; in the latitude of Toronto, in winter it is about six miles above the surface and about 70° F. below zero ; the observations would indicate that as the pole is approached the stratosphere is less than six miles above the earth and its temperature about 65° F. below zero and may be higher. Now temperatures lower than this have been recorded in the Mackenzie area and in Siberia, suggesting that either the stratosphere reaches to the earth's surface at these points or else there is a great inversion of temperature. The latter seems the more probable and that there may be a large increase of temperature upward before it again begins to decrease towards the stratosphere.

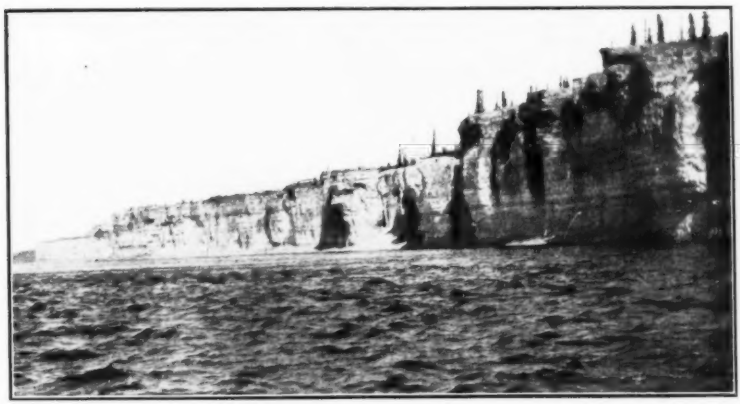


Photo by Bishop Breynault, O.M.I.

"THE RAMPARTS" (vertical walls of limestone and shale 125 to 250 feet high) Mackenzie River, near Fort Good Hope. At this point the river suddenly contracts from 3 miles to 500 yards, but in high water there is no sign of a rapid.

FORT McPHERSON (Lat. 67° 27′ N.). Taken on July 12 at midnight. About one-third of the sun is above the horizon (1 5/8 inches from left side of picture). Exposure 2 minutes.

Running a partly loaded scow over the Grand Cascade of Athabaska River. The bed of the river is limestone, and the fall is about six feet. In high water full loads are run over the Cascade.

# IS THERE A MORNING MAXIMUM OF THE AURORA?*

By A. F. Hunter

ABOUT twenty-five years ago, Dr. M. A. Veeder, of Lyons, N.Y., published several articles on the aurora, in the course of which he brought forward two important points:— (1) There is a time, two or three hours after sunset, when the aurora attains its maximum and tends to flare up with greater brilliancy than at any other time of the night. (2) When the conditions arising from the positions of sunspots, (with which phenomena the aurora seems to be intimately connected,) are favorable to displays of aurora being visible, we have, instead of the expected aurora, an outbreak of thunderstorms sometimes all over the whole of a continent; in other words, the aurora and the thunderstorm would appear to be interchangeable. Dr. Veeder's enunciation of these two fundamental principles is an example of how the work of an amateur may sometimes be in advance of the work of the professional men. He did not, however, indicate the existence of any other than the evening maximum of the aurora, and Professor Chant's curve of their diurnal frequency† shows substantially the absence of any other than the evening maximum. If the cathode theory of the aurora deserves the serious attention of the scientific world, and I believe it does, the question must be answered:— Why is there no morning maximum two or three hours before sunrise, just the same as the evening maximum two or three hours after sunset? Cathode rays coming up from the east would be bent around the earth just as much as those coming up from the west.

* Remarks made in the discussion upon a paper by the Editor on "The Aurora" at the meeting of the Society in Toronto, February 9, 1915.— Ed.

† Drawn from data in *Encyclopedia Britannica*, Vol. I., Art. "Aurora."—Ed.

There is nothing in the nature of the question to suggest any difference between the two circumstances, and the purpose of my present remarks is to describe some observations which may tend to throw light upon the morning maximum.

Soon after the publication of Dr. Veeder's articles, Professor Roentgen announced in 1895 his epoch-making discovery of X-rays, or rather his discovery of the method of recording their presence by photography, the radiations themselves having been known to scientific men before his time. The discovery created a great wave of popular interest, and immediately everyone interested in such phenomena became familiar with photographs of the bones in the hands and feet, as well as other marvellous appearances. It also became obvious at once why a flash of lightning may be seen with closed eyelids, — the X or other rays of the electric discharge passing through the eyelid and producing a strong effect upon the retina of the eye. The X-ray* effects of lightning occupied my attention, and I made calculations of the distances of the discharges in comparison with the effects produced upon the retina, the distance of a discharge being of course calculated by the time in seconds before the arrival of the sound of the thunder. Speaking generally, the X-ray effects of lightning discharges at a distance of more than five miles are feeble, yet many of the distant flashes are discernible when a person acquires familiarity with phenomena of the kind, notwithstanding that it is known by experiment that X-rays fall off rapidly in strength as they leave their source, on account of absorption by air.

After acquiring some familiarity with distant flashes of lightning in this way, I began to realize the existence of frequent distant electric discharges of some kind when there was no thunderstorm of any sort in the country around. The most rigid enquiry and search in meteorological reports failed to yield any trace of thunderstorms anywhere upon this continent at times when the retina of my eye, familiarized with the X-ray

* It is not suggested that these rays are certainly identical with those usually so-called, but the effects are somewhat similar.

effects of atmospheric electrical discharges, announced the occurrence of such phenomena. The flashes, unattended by electric storms, were of distant origin, as their effects were always feeble, and yet they were always as distinct as those having an origin in some distant thunderstorm. Phenomena of this kind are better observed in a wooden house than in a brick one, because the salts of iron or other substances in the bricks effectively screen the X-ray effects from an observer, and he receives only what reach him through the windows. For a similar reason a tin roof or other metallic covering destroys the value of a station for any observer. And there are other precautions that will be obvious to any person acquainted with X-rays who wishes to witness the X-ray effects of atmospheric discharges.

By accumulating a number of observations of such flashes of distant origin, unattended by electric storms, I was able to arrive at two inductive inferences regarding them: —

(1) For the most part they centre around the morning maximum of the aurora, or rather the time when such maximum might be expected, two or three hours before sunrise.

(2) They are coincident with a falling barometer, or just after a fall but not with a rising barometer; in other words, they belong to periods when the station of the observer is in the front of a cyclone, *i.e.*, when cirro-stratus clouds, an indispensable condition of the aurora, might be seen if daylight permitted their observation. These frequent, though distant, electric discharges in the atmosphere, of which the X-ray effects continually arrested my attention at the times when the morning auroral maximum would occur if the same conditions existed as in the evening, probably belong to the class of phenomena commonly known as sheet lightning, when it is viewed as an ordinary optical phenomenon.

Paulsen's cathode theory of the aurora came forward about the time when the chief characters of these phenomena began to force themselves upon me in the course of numerous observations, along with the development of the same theory by the excellent work of Messrs. Stormer and Birkeland in Norway,

and every difficulty became clear, at least to my own satisfaction, their studies on the aurora furnishing the explanation for every question that might arise. Remembering the interchangeable nature of the aurora and lightning, as pointed out by Dr. Veeder, we are not baffled by any difficulty over the apparent absence of a morning maximum. The electrification of the higher parts of the atmosphere, due to the cathode rays from the sun deflected into helixes around the earth by magnetic attraction, may take place morning and evening alike. But the dissipation of the charges when cirro-stratus clouds are present may take place in two different ways: —

(1) As a brush discharge, which we see as the aurora; or

(2) As the electric flash of lightning, either in a single stroke to the earth, or in a sheet from one cloud to another, the sheet-form being confined to the higher regions of the atmosphere where the air pressure is reduced, just as in the Plücker or Crookes tubes of our laboratories the single spark under normal pressure takes the diffused form under reduced pressure, and yet in both cases is attended with X-ray effects.

Under the same conditions as prevail in the evening, therefore, *viz.*, when cirro-stratus clouds are present in any quantity, the morning maximum appears at the time expected, but as it happens, the maximum is manifested in a way entirely different from the usual aurora of the evening. The hygrometric conditions of the atmosphere in the morning are totally different from those of the evening, as everyone knows from the deposition of dew, greater cloudiness and other common phenomena. And the changed conditions bring about the change we find in the method of dissipation of the electrification from the solar cathode rays.

The delicate retinal effects of atmospheric electric discharges, whether of distant lightning strokes, or of sheet discharges unattended by any storms, are not by any means new in science; text-books in physiology mention such phenomena, calling them all Photopsia, but so far as I have seen they give only vague unscientific conjectures of their origin, failing to recognize the

connection of at least a portion of them with X-ray effects and assigning them all to some morbid condition of the person's own optic nerve and organism.

It may also be of interest to mention that on two or three occasions since I became familiar with the X-ray effects on the retina of atmospheric electrical discharges, I have recognized "dark" flashes, that is, instantaneous withdrawals of existing light instead of pulses of actual light. In view of the recent announcement from Ottawa of the identification of dark flashes of lightning amongst the ordinary lightning strokes, the occurrence of similar phenomena amongst the X-ray effects upon the retina may be of some interest. It would seem that Milton's paradoxical "darkness visible" has a real existence, and I have been forced to wonder if Milton in his blindness, familiar with X-ray flashes, as many who are blind are known to be, had actually witnessed pulsations of the "dark" or inverted kind.

## MEETINGS OF THE SOCIETY

### At Hamilton

*January 15th, 1915.* — Mr. J. R. Collins, of Toronto, Secretary of the Royal Astronomical Society of Canada, delivered a lecture before the Local Centre this evening, on "A Trip to Labrador to Study and Photograph the Eclipse of the Sun," (1905). With the aid of over 100 lantern slides, the lecturer described the journey to the spot chosen in the wilds of Labrador, the preparation for the observing of the eclipse both as to installation of instruments and as to drill in the use of them. The final disappointment, owing to the eclipse being unseen because of clouds, was described, as was also the return journey.

Two photographs showing the weird light stealing over the landscape as the eclipse began were especially fine.

*January 27th.*— The Local Centre enjoyed the pleasure of listening to Dr. J. S. Plaskett, of Ottawa, the President of the parent Society, on the subject "Particulars of the Largest Telescope in the World, now being made for Canada."

The various kinds of reflecting telescopes were described with special reference to the means adopted for easily changing from one form to the other.

The fineness and accuracy of the optical and mechanical parts were described, with the different slow and fast motions, also the kind of work it is expected will be undertaken with the aid of this telescope.

It is expected that stars to the 18th or 19th magnitude will

be accessible, and spectrographic work will be undertaken on much fainter stars than has been possible up till the present.

The location and reasons for choosing the same were also described.

*February 26th.*—Mr. John Patterson, M.A., of the Meteorological Service, gave a very interesting lecture before the Local Centre on "A 1200-Mile Trip to Fort McPherson, near the Mouth of the Mackenzie River." This trip was undertaken with the view of inspecting the various posts where observations are being taken and also for the giving of instruction in the work of observing the direction and force of the winds.

The mode of travel, the inhabitants and surroundings of the various stations were described, together with the various incidents of the journey.

The lines of equal temperature, with the highest and lowest readings of the thermometer were shown.

The lowest was 77° below zero although 92° had been claimed as having been observed in Asia.

T. H. W.

## NOTES FROM THE DOMINION OBSERVATORY

### THE RADIAL VELOCITY OF 1 CASSIOPEIÆ

From time to time as the observing program will permit, spectrograms of stars, other than those on our regular list, are made here, one purpose of this being to discover new binaries Recently Professor Frost suggested that we observe the star *1 Cassiopeiæ* ($\alpha = 23^h\ 02^m$, $\delta = +58°\ 53'$, photographic magnitude 4·7). Five plates had been secured at Yerkes with a range, as communicated later, from + 1 to − 16 km. per sec. and while ranking it as a binary Professor Frost believed that a considerably larger range in its velocity might be discovered. Professor Campbell quotes its velocity in *L. O. B.* 195, as − 2·0 km. per second.

Nine plates have recently been made here. In addition to several fair lines of helium and hydrogen the *H* and *K* lines of calcium are fairly sharp though the former is usually too confused with $H_\epsilon$ to measure. From six to ten lines are used on each plate. The weighted mean of our measures is − 10·0 km. per sec. While the probable error of a plate of ± 2·8 km. per sec. (on the assumption of constant velocity of − 10·0 km. per sec.) is only about 25 per cent. greater than we get here for stars of this type with single prism dispersion, yet the difference of 8 km. between our measures and those of the Lick Observatory would seem to bear out Frost's statement as to its binary character and shows the need of further observations. The star is now too close to the sun for further work this season. The measures obtained follow.

| Date | Velocity | Weight |
|---|---|---|
| 1914 December 10·55 | − 17.6 | 7 |
| " 11·52 | − 3·8 | 6 |
| " 15·44 | − 10·3 | 5 |
| " 16·61 | − 10·3 | 8 |
| " 22·52 | − 12·0 | 8 |
| " 30·44 | − 9·5 | 6 |
| 1915 January 5·44 | − 12·5 | 8 |
| February 10·50 | − 9·5 | 5 |
| " 18·48 | − 3·6 | 8 |

W. E. HARPER.

## REVIEW OF PUBLICATION

*Contributions from the Princeton University Observatory*, No. 3. *A Study of the Orbits of Eclipsing Binaries*. By HARLOW SHAPLEY.

Some three years ago Professor H. N. Russell, of Princeton University Observatory, dealt with the problem of determining the elements of the component stars of an eclipsing variable from its observed light curve. In papers published in the *Astrophysical Journal* in June and July, 1912, he discussed under what circumstances and to what degree the problem was determinate and he developed formulæ and tables for use when such was the case. Shapley, Fellow in Astronomy at Princeton at the time, then undertook the discussion of the light curves of those eclipsing variables which were sufficiently observed and in the above publication we have the results for 90 of these variables.

Eclipsing variables, as their name implies, are stars varying in brightness owing to the mutual eclipses of the two components as they revolve about each other in their orbits. They have been called *Algol* variables from the well-known star Algol ($\beta$ Persei) which is of this class. The conditions which favor eclipses, and which make them readily observable, we can easily see are two. The planes of revolution of such systems must coincide, or nearly so, with the line of sight and the distances separating the components must be relatively small. As a result of the small linear dimensions of the orbit we are led to expect that the periods of these variables will be short. Half of the number discussed have periods of three days or less and from

what we have learned from spectroscopic work as to the connection between short periods and early type stars we are not surprised that the early *B* and *A* types constitute about 75 per cent. of the number. There are thirteen brighter than 7·5 magnitude at minimum. Of the remainder the bulk are fainter than 10·0 magnitude, so that we could not hope to obtain much spectroscopic data regarding them, even using the largest telescopes. Orbits of most of those brighter than 7·6 magnitude have been determined spectroscopically.

The principal requirement in this work is a well determined light curve. For some stars there is a wealth of observational material, but Shapley has found it advisable, in these cases, to base his computations upon some particular observer's work which seems the best, rather than to attempt to harmonize all available observations. No eclipsing star has been omitted, he says, for which a passable light curve exists. Seven kinds of photometers and ten different methods of observing have been used by the various astronomers whose work is included. The photometric work by Wendell, and the visual observations by Nijland each afford eighteen light curves, while from the Harvard photographic plates Miss Leavitt has contributed eleven curves. Shapley himself has seven ; Roberts six ; while a score of other observers make up the balance. Contrary to much that has been published regarding irregularities in light curves, it is found that well determined light curves are in general symmetrical, smooth and regular. The better observed the curve, the more free it is from irregularities.

In developing the formulæ a number of assumptions had to be made but on the whole those made seem only reasonable. For instance, in short period binaries we know from spectroscopic data that the orbit is nearly circular, so it is only reasonable to assume it such in these stars. In a few cases he was able to detect an appreciable eccentricity from the better observed light curves. Probably the most important assumption made is that of "darkening at the limb." We know from the study of the sun that there is a diminution of intensity as we go from the

centre of the disc to the limb and we may expect similar conditions to hold for other stars. Shapley makes two solutions for each star termed *uniform* and *darkened*; the former to cover the case where the disc is assumed to be uniformly luminous, and the latter where the limb is completely darkened. On these two extremely different assumptions complete orbits have been obtained.

In chapter III. is discussed the solution for several stars each of which can be considered as a type of a certain kind of variation. Thus we have total eclipses with minimum light constant, partial eclipses with one or both minima observed, maximum light not constant, etc., etc., and special cases in which the light curve being well defined he can detect such effects as of "*periastron*" and "*reflection.*" He treats also of the aid spectroscopic observations bring to bear in the computation of the masses, densities and dimensions.

In the catalogue which summarizes the work he has classified the orbits into four groups. The first group of 31 stars includes all those well determined; the second, 24 in number, those stars fairly well observed but further photometric work is necessary to make the orbital elements definitive; the third list of 17 includes those stars insufficiently observed; while the fourth group comprises Nijland's 18 visually determined light curves, some of which may be of a high order of accuracy while others are more of a provisional nature.

While the main purpose of the investigation was the computation of the orbits, yet some information is obtained as to the general characteristics of these doubles, their origin and development. The existence of darkening at the limb is borne out by the better representation of the observations by the computed light curves based upon the theory of darkening. Considered in connection with the measured darkening at the limb of the sun — a *G*-type star — it affords evidence that pronounced atmospheric absorption is a characteristic of eclipsing and spectroscopic binaries of all spectral types.

In the majority of the cases the fainter component has the

greater volume but, as pointed out, this is not to be considered as the rule because when stars of lesser light range shall have been discovered, as is bound to be the case with the improved modern photometers, the ratios of the size of the components will also change. The evidence goes to show that the large relatively dark companions are of low density and may be assigned to a different period in stellar evolution than their denser primaries. Furthermore the *A*-type stars seem to have extremely low densities as a class.

The parallaxes of only three or four of these systems have been measured directly but the results bear out the conclusion reached by Shapley, from a hypothetical study of these stars, that efforts to determine their parallaxes would be useless, so far distant are they. When discussed with regard to their distribution in the sky their marked condensation into the plane of the Milky Way is at once obvious, and using the hypothetical parallaxes obtained, the disc-like formation of the Milky Way is borne out.

The book is a valuable contribution to our knowledge of the stellar world and it paves the way for similar work along the line of photometric observations of variable stars of this class, many of which are known to exist but whose light curves have never been determined.

W. E. Harper.

## NOTES FROM THE METEOROLOGICAL SERVICE

### Summary Report of the Weather in Canada

### February, 1915

*Temperature.* — The mean temperature of the month was considerably above the normal in all parts of the Dominion. From Lake Superior westward to the Rockies the positive departures, except in Northern Alberta, ranged between 10 and 17 degrees. In the vicinity of Edmonton and in British Columbia the excess was from 3 to 4 degrees, and from the Great Lakes to the Maritime Provinces from 2 to 8 degrees.

*Precipitation.* — In British Columbia and over the greater part of the Western Provinces the precipitation was considerably below the normal, and in many sections of the prairies it was extremely light. In Ontario and Quebec departures from average were nowhere large, and were positive in some localities and negative in others. In the Maritime Provinces, while the total amount was not particularly light, it was below the average in nearly all districts.

*Depth of Snow.* — In the Western Provinces, while bare ground was visible in some places at the close of the month, most of the country had a thin covering of snow, and in Southern Alberta a depth of ten to twelve inches was reported, with a crusted surface in some sections. In Southern Ontario the fields were practically bare and only drifts remained, but in the eastern part of the Province there was a covering in most places of two

to eight inches. In the Georgian Bay Region and northern districts, however, the snow ranged from six inches to two feet in depth. In Quebec the depth was from one inch to eight inches in the western part of the Province, and from fourteen to thirty-six inches farther east. Snow was fairly deep in the interior of New Brunswick, but in the southern part of that Province and in Nova Scotia, the ground was practically bare.

## Temperature for February, 1915

| Station | February | |
|---|---|---|
| | Highest | Lowest |
| *Yukon* | | |
| Dawson | | |
| *British Columbia* | | |
| Atlin | | |
| Agassiz | 55 | 28 |
| Barkerville | | |
| Kamloops | 50 | 24 |
| New Westminster | 58 | 28 |
| Prince Rupert | 56 | 28 |
| Vancouver | 54 | 28 |
| Victoria | 52 | 34 |
| *Western Provinces* | | |
| Battleford | 35 | 15 |
| Broadview | | |
| Calgary | 46 | 0 |
| Carman | | |
| Edmonton | 41 | -13 |
| Medicine Hat | 43 | - 9 |
| Minnedosa | 34 | -19 |
| Moose Jaw | 40 | - 4 |
| Oakbank | 38 | -14 |
| Portage la Prairie | 32 | -15 |
| Prince Albert | 33 | -12 |
| Qu'Appelle | 39 | - 5 |
| Regina | 40 | - 9 |
| Swift Current | 40 | 3 |
| Winnipeg | 38 | 13 |
| *Ontario* | | |
| Agincourt | 41 | 4 |
| Aurora | 40 | -12 |
| Bancroft | 41 | -19 |
| Barrie | | |
| Beatrice | 43 | -16 |
| Birnam | 49 | 0 |
| Bloomfield | | |
| Brantford | 42 | -13 |
| Bruce Mines | | |
| Chatham | 55 | 3 |
| Clinton | 42 | - 3 |
| Cottam | | |
| Gravenhurst | 57 | -22 |
| Guelph | | |
| Haliburton | 46 | -20 |
| Hamilton | 42 | - 2 |
| Huntsville | | |
| Kenora | 35 | -13 |
| Kinmount | 42 | -23 |
| Kingston | 45 | - 5 |
| Lakefield | | |
| London | 48 | - 3 |
| Lucknow | 40 | -20 |
| Madoc | | |
| Midland | 41 | 8 |
| North Gower | | |
| Otonabee | | |
| Ottawa | 45 | -12 |
| Owen Sound | | |
| Paris | 41 | - 9 |
| Parry Sound | 45 | -11 |
| Peterboro' | 43 | -15 |
| Port Arthur | 38 | -16 |
| Port Burwell | 47 | - 3 |
| Port Dover | 43 | -14 |
| Port Stanley | 45 | - 1 |
| Ronville | 43 | -21 |
| Sarnia | | |
| Southampton | 47 | 2 |
| Stonecliffe | 42 | -20 |
| Stony Creek | 44 | - 6 |
| Stratford | | |
| Toronto | 42 | 3 |
| Uxbridge | 42 | -14 |
| Wallaceburg | 55 | - 1 |
| Welland | 49 | 2 |
| White River | 42 | -33 |
| *Quebec* | | |
| Brome | 47 | 11 |
| Father Point | 37 | 18 |
| Montreal | 41 | -10 |
| Quebec | 35 | -12 |
| Sherbrooke | 44 | - 6 |
| *Maritime Provinces* | | |
| Charlottetown | 46 | 12 |
| Chatham | 43 | -24 |
| Dalhousie | | |
| Fredericton | 44 | 19 |
| Halifax | 47 | -11 |
| Moncton | | |
| St. John | 47 | 10 |
| St. Stephen | 48 | -12 |
| Sussex | 53 | -18 |
| Sydney | 49 | - 9 |
| Yarmouth | 49 | 2 |

## Earthquake Records by the Milne Seismograph

### TORONTO

R. F. Stupart, Director.

P. T. = Preliminary Tremors. L.W. = Large Waves. A.C. = Air Currents.
Time is Greenwich Civil Mean Time, 0 or 24 h = midnight.

| No. | Date 1915 | P. T. Comm. | L.W. Comm. | Max. | End | Max. Amp. | Durat. | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | h m | h m | h m | h m | mm. | h m | |
| 1439 | Feb. 25 | 9 13·0 ) 9 15·6 ) | 9 23·0 | 9 24·5 | 9 31·1 | 0·4 | 0 18·1 | |
| 1440 | " 25 | | 15 23·0 | | 15 33·0 | 0·05 | 0 10·0 | |
| 1441 | " 25 | 20 54 8 | 21 03·4 | 21 04·7 | A.C. | 0·3 | | |
| 1442 | " 28 | 19 24·9 | 19 55·4 ) 20 0·4 ) | 20 3·2 ) 20 7·4 ) | 21 24·0 | 0·5 0·4 | 1 59·1 | |

Boom period 18 seconds. Pillar deviation 1 mm. = 0″·59.

### VICTORIA, B. C.

F. N. Denison, Superintendent.

| No. | Date 1915 | P.T. Comm. | L.W. Comm. | Max. | End | Max. Amp. | Durat. | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | h m | h m | h m | h m | mm. | h m | |
| 1447 | Feb. 25 | 9 03·6 | 9 05·6 | 9 06·6 | 9 18·6 | 1·2 | 0 15·0 | 800 km. |
| 1448 | " 25 | 15 07·1 | | 15 08·1 | 15 11·6 | 0·2 | 0 4·5 | |
| 1449 | " 25 | 20 51·0 | 20 57·0 | 20 57·5 | 21 47·5 | 0·5 | 0 56·5 | |
| 1450 | " 28 | 19 22·4 | 19 46·9 | 20 03·4 | 20 35·4 | 0·5 | 1 13·0 | |

Boom period 18 seconds. Pillar deviation 1 mm. = 0″·54

J. Y.

## MAGNETIC OBSERVATIONS

During the greater part of February the Agincourt Magnetic curves indicated more or less disturbance in the Magnetic Forces, the period from the 13th to the 18th alone being undisturbed. The maximum disturbance occurred on the 19th and 20th and was marked by its duration and the rapidity of change in direction and force, rather than by changes of large amplitude.

Another disturbed period was at its maximum on the 8th. During both these disturbed periods auroræ were observed in all parts of Canada and notably in Alberta.

| February, 1915 | | D. West | H | V | I |
|---|---|---|---|---|---|
| | | ° ′ | | | ° ′ |
| | Mean of Month | 6 27·0 | 0·16045 | 0·58701 | 74 42·9 |
| | Maximum | 6 48·9 | 0·16087 | 0·58753 | |
| | Date of Maximum | 23 | 25 | 19 | |
| | Minimum | 6 04·4 | 0·15991 | 0·58666 | |
| | Date of Minimum | 19 | 9 | 8 | |
| | Monthly Range | 0 44·5 | 0·00096 | 0·00087 | |
| Mean Daily Amplitude | From hourly readings | 0 6·6 | 0·00020 | 0·00008 | |
| | From Means of Extremes | 0 13·4 | 0·00047 | 0·00019 | |

H and V are expressed in C. G. S. Units.

I is the Mean of all Dip observations made during the month with the Earth Inductor, without regard to the time of day at which they were made. Two observations are usually made each week.

## COMET NEWS

### THE ORBIT OF MELLISH'S COMET

The orbit published last month was stated to be uncertain as several solutions were possible with the data used in its computation. In Harvard *Bulletin*, No. 579, new elements and ephemeris are given, computed by Professor Crawford and Miss Young, at the Students' Observatory, Berkeley, California, from observations on February 13, 17 and 27.

ELEMENTS

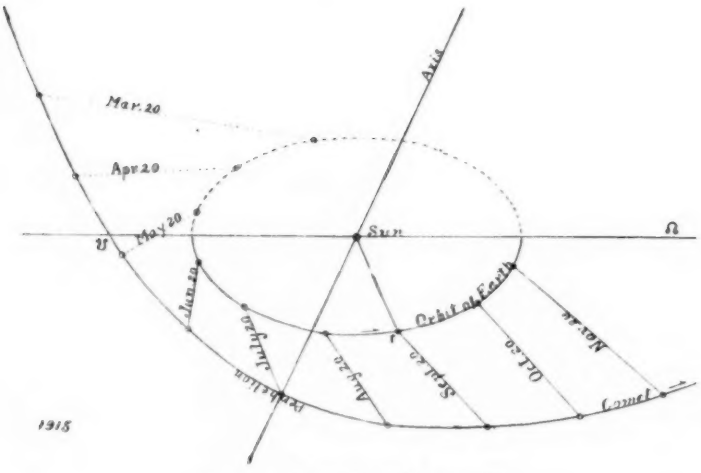
| | | |
|---|---|---|
| Time of perihelion passage | ($T$) | July 20·55, G.M.T. |
| Perihelion minus node | ($\omega$) | 244° 26′ |
| Longitude of node | ($\Omega$) | 73° 39′ |
| Inclination | ($i$) | 53° 28′ |
| Perihelion distance | ($q$) | 1·075. |

EPHEMERIS

| G.M.T. | R.A. | | | Decl. | | | |
|---|---|---|---|---|---|---|---|
| | h | m | s | ° | ′ | | |
| 1915 March 5·5 | 17 | 31 | 53 | + 1 | 23 | | 1·79 |
| 9·5 | 17 | 36 | 52 | + 1 | 03 | | |
| 13·5 | 17 | 41 | 50 | + 0 | 41 | | |
| 17·5 | 17 | 46 | 46 | + 0 | 17 | | 2·67 |

By looking up Map III. of the Constellations in the HANDBOOK, the comet's position amongst the stars can be seen.

Dr. R. K. Young, of Ottawa, has supplied the accompanying drawing of the orbit, and he gives the following information.




ORBIT OF MELLISH'S COMET

In the diagram, the orbit of the earth is projected on to the plane of the comet. The lines joining the two orbits give the relative positions of the earth and comet on the dates indicated. The comet will move eastward and south and will grow rapidly brighter till the middle of July when it passes perihelion. Its southern declination at that time will render it of little interest to Canadian observers. After perihelion, its motion is slower and it will grow slowly fainter being visible till the end of the year. At that time it will still be below the ecliptic.

C. A. C.

## ASTRONOMICAL NOTES

Recent Stellar Work at Mount Wilson Solar Observatory. — (23) The object N. G. C. 6760, described as a variable nebula, has been found to be a star-cluster showing no traces of nebulosity.

(24) The first complete determinations of stellar parallax with the 80-foot Cassegrain combination of the 60-inch reflector are very satisfactory.

(25) The measurement of the magnitudes of some 600 stars near the North Pole establishes the photographic scale from the second to the twentieth magnitude.

(26) As previously found, the magnitudes are in close agreement with the Harvard results for the interval 10·5–15·5, but there are divergences for both bright and faint stars.

(27) A determination of the photovisual scale for magnitudes 2 to 17·5 has been made.

(28) A comparison of photographic and photovisual magnitudes shows that the minimum color index of the whitest stars increases with increasing magnitude, indicating that the fainter stars are redder than the brighter ones.

(29) A determination of the photographic and photovisual light curves of the cluster-type variable star RS Bootes indicates a marked change of color with magnitude, in harmony with observations of a simultaneous change in spectrum.

(30) The total number of constant-velocity stars for which radial velocities have been determined is now 545, an increase of 173 during the year.

(31) The velocities of 100 parallax stars published since the 1st report are of special interest. Twenty of these (corrected for the sun's motion) exceed 50 km. and 6 exceed 100 km., the highest being 319 km.

(32) Two *A*-type stars of high constant velocity (over 100 km.) have been found.

(33) Several pairs of optical double stars are indicated by their equal velocities to be physically connected.

(34) The star O. Arg. S. 14320 is found to have the enormous velocity in space of 577 km. per second.

(35) There have been 16 new spectroscopic binaries discovered, making the total number 115.

(36) Comparative photographs on the same plate of the spectra of near and distant stars show that the latter are, in general, much fainter in the violet.

(37) Photometric measures of 151 photographs of stellar spectra confirm this result, and show that the amount of the effect depends upon the spectral type, being twice as great for $K_0$-$K_4$ stars as for $F_0$-$F_5$ stars.

(38) As the average differences of proper motion for the groups observed in each case are closely the same, the observed effect for these stars must be due mainly to differences in physical condition.

(39) The hydrogen lines are abnormally strong in certain small proper-motion stars. This is due mainly, if not wholly, to the physical condition of these stars, and not to hydrogen gas in space.

(40) Certain other spectrum lines are weak in the large proper-motion stars and strong in the small proper-motion stars, and conversely.

(41) The relative intensities of these lines have permitted the absolute magnitudes of known-parallax stars to be computed. The method promises to give a satisfactory means of determining a star's parallax from the relative intensities of these lines when its apparent magnitude is known.

(42) The observed disappearence of the chief nebular lines

makes the spectra of Nova Aurigæ and Nova Persei identical with those of certain Wolf-Rayet stars, suggesting that the latter may be temporary stars in the later stages of their history.—*Directors Annual Report* for 1914.

GRAVITATION. — It is scarcely too much to say that the nature of gravitation remains as much a mystery to-day as when the law was first formulated by Sir Isaac Newton. In the meantime, theories of matter, or æther, and of electricity have arisen, have held their vogue, and have been superseded by others; but gravitation stands apart from these changing views. No experiments have as yet shown any relation between it and the other phenomena of nature; the simple law, unconditional and universal, has been all-sufficient hitherto. We have grown accustomed to regarding gravitation as something outside the scope of ordinary physical theories. If a new model of the atom is put forward, we ask if it accounts for the Zeeman effect, for chemical affinity, for the dispersion of light, and a host of incidental phenomena; but it would be considered unfair to suggest that it ought to account for the one fundamental and universal property of matter — gravitation.

The extreme weakness of the force of gravitation compared with electrical and magnetic forces has often been pointed out. The value of gravitation-constant in C.G.S. units is $6{\cdot}66 \times 10^{-8}$. This makes the gravitational attraction between two singly charged hydrogen atoms only $7{\cdot}9 \times 10^{-37}$ of their electrostatic repulsion. A survey of the known constants of physics does not encourage the idea that such a factor as this (necessarily of zero dimensions) can be made up by any conceivable combination. It seems clear that gravitation must introduce a new and independent fundamental unit, which has not hitherto appeared in any other branch of physics. If the new unit is expressed as a length, that length must be of a widely different order of magnitude from the lengths implied in the other constants of nature — that is to say, from the wave-lengths and electronic dimensions that are dealt with in modern theories of matter; and

it is therefore not surprising that in these theories gravitation is considered irrelevant.

The consideration of how mass, and therefore gravitation, is affected by motion brings us to the question whether the attraction is propagated instantaneously or with a finite velocity. In particular is it, like an electrical property propagated with the speed of light? It has often been stated erroneously that the velocity of gravitation, if finite at all, must enormously transcend that of light. Many great authorities might be cited as offenders. There is in reality no objection, on astronomical or other grounds, to our accepting the view that gravitation is propagated with the velocity of light. The mistake appears to have arisen from the supposition that, if the speed is finite, the attraction of one body $A$ on another body $B$ is directed, not towards $A$'s present position, but towards the position $A$ occupied at an instant some time previous corresponding to the time of propagation. If this were true, it would undoubtedly produce important effects in astronomy. For example, the attractions of Jupiter on the Sun and of the Sun on Jupiter would no longer act in the same line, but would form a couple tending to increase the angular momentum of system. The effect would be so rapid as to be easily detected by observation. But it is very unlikely that gravitational force could be propagated in the way this implies. It is not the force on Jupiter that can be regarded as travelling outwards from the Sun, but a potential (for the actual *force* involves Jupiter's mass). The motion of the source involves certain necessary modifications in calculating the potential which are well-known in electrical theory. Assuming that the gravitation potential is exactly analogous to electrostatic potential, the result is that a body moving uniformly with velocity $v$ attracts another body exactly as though it was at rest in its present position, so far as the first order in $v/V$ (where $V$ is the velocity of gravitation). In other words, the attraction is directed towards the present, and not the antedated, position of the attracting body. — Professor Eddington, in the *Observatory*, No. 484. J. R. C.

## NOTES AND QUERIES

**Communications are Invited, Especially from Amatuers. The Editor will try to Secure Answers to Queries.**

### Query

"During the month of February there will be no full moon. If you look at a calendar you will see there was a full moon on January 30 and there will be one on March 1, but none in February. This is the second time since the creation of the world that such an astronomic marvel has taken place, and it is predicted by skilled observers of the heavenly bodies that the phenomena will not occur again for two million five hundred thousand years."

I have been written to by a party who sent me the enclosed newspaper clipping re the moon being full twice in one month, and no full moon in February, and this has happened once only since the Jewish account of the creation and will not happen again for 2,500,000 years. Can you enlighten me on this problem? — W. Bruce, Hamilton.

### Answer

Where did the newspaper get its information? On reading such paragraphs that question is always suggested. I am not inclined to make any general accusation against our daily or weekly papers as they seem generally careful in publishing their news, but one would wish that such lapses as the above would not occur.

The task of computing all the months of February which have been without a full moon is a serious one, but reference to almanacs for a series of years soon shows the wild nature of the statement made. With the assistance of Mr. F. L. Blake, of the Meteorological Office, the *Nautical Almanacs* from 1822 to 1916 were examined with the following results :—

There was no *new moon* in February 1851, 1870, 1889.

There was no *first quarter* in February 1830, 1849, 1887.

There was no *full moon* in February 1828, 1847, 1874, 1893, 1915.

There was no *last quarter* in February 1834, 1853, 1864, 1883, 1902.

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## VELOCITIES OF THE NEBULÆ AND THE STARS

The problem of the universe will long remain the grandest subject for the student of physical science to investigate. A very lucid outline of the leading views now held regarding the evolution of the stars was given by Dr. J. S. Plaskett, in his presidential address printed in the last number of the JOURNAL.

Some of the most remarkable recent results bearing upon this question are the extraordinary velocities in space possessed by some of the nebulæ, considerable effort having been devoted to this matter during the last two or three years at the Lowell and the Lick Observatory.

Dr. V. M. Slipher, of the former institution, gives the following list of radial velocities of *spiral* nebulæ, though it is to be understood that in some cases the values are only provisional.

| Nebula | Radial Velocity | Remarks |
|---|---|---|
| N. G. C. 221 | − 300 km. per sec. | These nebulæ lie to the south of the Milky Way |
| 224 | − 300 | |
| 598 | − | |
| 1023 | + 200 roughly | |
| 1068 | + 1100 | |
| 7331 | + 300 | |
| 3031 | + small | These lie to the north of the Milky Way |
| 3115 | + 400 roughly | |
| 3627 | + 500 | |
| 4565 | + 1100 | |
| 4594 | + 1100 | |
| 4736 | + 200 roughly | |
| 4826 | + small | |
| 5194 | + small | |
| 5866 | + 600 | |

From the values so far obtained by Slipher the average velocity is about 400 km. per second, which is about 25 times the average stellar velocity.

Campbell reports similar results obtained at the Lick Observatory though the average there is not so high. For 40 observed *planetary* nebulæ the average velocity is over 40 km. per second.

It has also been shown by Campbell (and corroborated independently by Kapteyn and Boss) that the average velocity of the *A*-type stars, which are ordinarily considered to be the 'youngest' in order of development, is 6 km. per second; while that of the *M*-type or 'oldest' stars is about 17 km. per second.

Further, it has been the prevailing view for many years that the early type stars are formed from nebulæ, probably of the planetary form. But the new determinations of velocities of nebulæ seem to separate them widely from the stars, especially from those of early type. Our views on the evolution of the stars must be revised to fit the new experimental results.

It is true that individual stars have been found which possess very high velocities, and some of these have been referred to already in "Notes and Queries". At Mount Wilson 20 stars have been discovered which have radial velocities exceeding 50 km. per second; 6 show velocities of over 100 km., the greatest being that of Lalande 1966, which is − 319 km. Two stars of *A*-type show velocities exceeding 100 km. Recent observations of a star of 9·2 magnitude, known as O. Arg. S. 14320, indicate that its velocity in space is exceptionally great. Its radial velocity is + 290 km. per second, and from its well-determined parallax of 0″·035 and its proper motion of 3″·76 annually, it has been found that the star's total velocity in space is 577 km. per second. These velocities, however, are exceptional, while the usual nebular velocity is high.

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## ELECTRICAL PHENOMENA ON MT. HAMILTON

In the introduction to his volume of photographs of the

Milky Way and of Comets, reviewed in last month's JOURNAL, Professor Barnard recounts some interesting observations of electrical phenomena on Mt. Hamilton. As is well-known, electrical storms are rare there.

On some cold nights, when dressed in a fur coat and heavy rubber overshoes, an annoying spark would discharge between the eye and the eyepiece of the telescope. On one occasion, also, when going to bed in the early morning, rubbing the hands over the sheets produced a perfect shower of sparks, apparently threatening to set the sheets on fire.

The present writer had a similar experience on his last stay in one of the hospitable homes on the summit at the end of August, 1910. On throwing back the bed-covering there was a great crackling and a splendid exhibition of sparks.

C. A. C.